

This **Simplified Block Diagram** represents a LOCIS added to a flight-control system that includes a single control surface.

Current commercial aircraft exhibit uneven responses of primary flight-control surfaces to aggressive pilot control commands, leading to deterioration of pilots' ability to control their aircraft. In severe cases, this phenomenon can result in loss of control and consequent loss of aircraft. For an older aircraft equipped with a purely mechanical control system, the loss of harmony between a pilot's command action and the control-surface response can be attributed to compliance in the control system (caused, for example, by stretching of control cables, flexing of push rods, or servo-valve distortion). In a newer aircraft equipped with a fly-by-wire control system, the major contributions to loss of harmony between the pilot and the control surfaces are delays attributable to computer cycle time, control shaping,

filtering, aliasing, servo-valve distortion, and actuator rate limiting. In addition, a fly-by-wire control system provides no tactile feedback that would enable the pilot to sense such features of the control state as surface flutter, surface jam, position limiting, actuator rate limiting, and control limiting imposed by the aircraft operational envelope.

Hence, for example, when a pilot is involved in aggressive "closed-loop" maneuvering, as when encountering a wake-vortex upset on final landing approach, the control-surface delay can lead to loss of control. Aggressive piloting can be triggered and exacerbated by control-system anomalies, which the pilot cannot diagnose because of the lack of symptoms caused by the absence of feedback through the controls. The purpose served by a LOCIS is to counter-

act these adverse effects by providing real-time feedback that notifies the pilot that the aircraft is tending to lag the pilot's commands.

A LOCIS (see figure) includes cockpit control input-position sensors, control-surface output-position sensors, variable dampers (for example, shock absorbers containing magneto-rheological fluids such that the damping forces can be varied within times of the order of milliseconds by varying applied magnetic fields) attached to the cockpit control levers, electromagnet coils to apply the magnetic fields, and feedback control circuits to drive the electromagnet coils. The feedback control gains are chosen so that the current applied to each

electromagnet coil results in a damping force that increases in a suitable nonlinear manner (e.g., exponentially) with the difference between the actual and commanded positions of the affected control surface. The increasing damping force both alerts the pilot to the onset of a potentially dangerous situation and resists the pilot's effort to command a control surface to change position at an excessive rate.

*This work was done by Ralph C. A'Harrar of NASA Headquarters. Further information is contained in a TSP (see page 1).*

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center, at (757) 864-3521. Refer to LAR-16566.*

## Improved Underwater Excitation-Emission Matrix Fluorometer

**This is a higher-resolution, smaller, more-capable successor to a prior instrument.**

*Stennis Space Center, Mississippi*

A compact, high-resolution, two-dimensional excitation-emission matrix fluorometer (EEMF) has been designed and built specifically for use in identifying and measuring the concentrations of organic compounds, including polluting hydrocarbons, in natural underwater settings. Heretofore, most EEMFs have been designed and built for installation in laboratories, where they are used to analyze the contents of samples collected in the field and brought to the laboratories. Because the present EEMF can be operated

in the field, it is better suited to measurement of spatially and temporally varying concentrations of substances of interest.

In excitation-emission matrix (EEM) fluorometry, fluorescence is excited by irradiating a sample at one or more wavelengths, and the fluorescent emission from the sample is measured at multiple wavelengths. When excitation is provided at only one wavelength, the technique is termed one-dimensional (1D) EEM fluorometry because the resulting matrix of fluorescence emission data (the EEM)

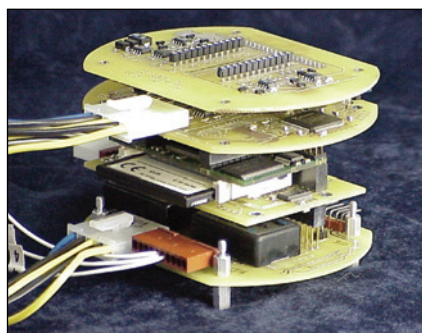
contains only one row or column. When excitation is provided at multiple wavelengths, the technique is termed two-dimensional (2D) EEM fluorometry because the resulting EEM contains multiple rows and columns.

EEM fluorometry — especially the 2D variety — is well established as a means of simultaneously detecting numerous dissolved and particulate compounds in water. Each compound or pool of compounds has a unique spectral fluorescence signature, and each EEM is rich in information

content, in that it can contain multiple fluorescence signatures. By use of deconvolution and/or other mixture-analyses techniques, it is often possible to isolate the spectral signature of compounds of interest, even when their fluorescence spectra overlap.

What distinguishes the present 2D EEMF over prior laboratory-type 2D EEMFs are several improvements in packaging (including a sealed housing) and other aspects of design that render it suitable for use in natural underwater settings. In addition, the design of the present 2D EEMF incorporates improvements over the one prior commercial underwater 2D EEMF, developed in 1994 by the same company that developed the present one. Notable advanced features of the present EEMF include the following:

- High sensitivity and spectral resolution are achieved by use of an off-the-shelf grating spectrometer equipped with a sensor in the form of a commercial astronomical-grade 256×532-pixel charge-coupled-device (CCD) array.



This **Assembly of Electronic-Circuit Boards** takes up significantly less room than would a conventional assembly containing circuits that perform the same variety of functions. The CCD, shown here, is mounted onto pins on the top board.

- All of the power supply, timing, control, and readout circuits for the illumination source and the CCD, ancillary environmental monitoring sensors, and circuitry for controlling a shutter or filter motor are custom-designed and mounted compactly on three circuit boards below a fourth circuit board that holds the CCD (see figure).

- The compactness of the grating spectrometer, CCD, and circuit assembly makes it possible to fit the entire instrument into a compact package that is intended to be maneuverable underwater by one person.
- In mass production, the cost of the complete instrument would be relatively low — estimated at approximately \$30,000 at 2005 prices.

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*Refer to SSC-00235, volume and number of this NASA Tech Briefs issue, and the page number.*

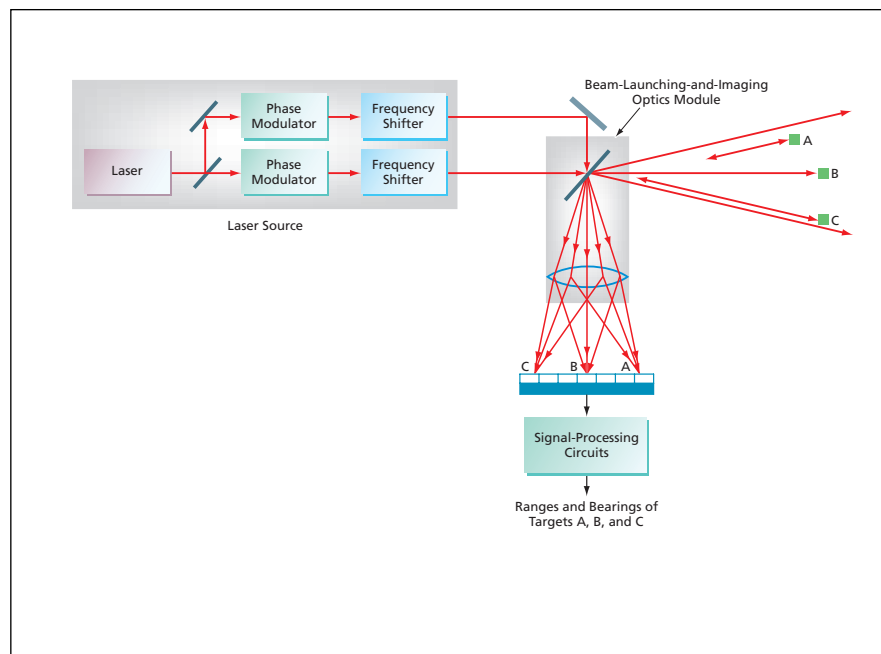
## Metrology Camera System Using Two-Color Interferometry

**3D locations of multiple targets are determined without mechanical scanning.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A metrology system that contains no moving parts simultaneously measures the bearings and ranges of multiple reflective targets in its vicinity, enabling determination of the three-dimensional (3D) positions of the targets with submillimeter accuracy. The system combines a direction-measuring metrology camera and an interferometric range-finding subsystem. Because the system is based partly on a prior instrument denoted the Modulation Sideband Technology for Absolute Ranging (MSTAR) sensor and because of its 3D capability, the system is denoted the MSTAR3D. Developed for use in measuring the shape (for the purpose of compensating for distortion) of large structures like radar antennas, it can also be used to measure positions of multiple targets in the course of conventional terrestrial surveying.

A diagram of the system is shown in the figure. One of the targets is a reference target having a known, constant distance with respect to the system. The system comprises a laser for generating local and target beams at a carrier frequency; a frequency shifting unit to introduce a frequency shift offset between



The **MSTAR3D** measures the bearings of targets in the manner of a star tracker and the ranges of targets by use of heterodyne interferometry.

the target and local beams; a pair of high-speed modulators that apply modulation to the carrier frequency in the

local and target beams to produce a series of modulation sidebands, the high-speed modulators having modulation